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wilderness that they might be free to worship God after their own fashion, and to remain out of sight and hearing of those who either did not worship at all, or who followed after prelates and presbyters. They were not restless fanatics, with hot heads, hasty tempers, and feeble intellects; they showed a cool and sound judgment in their ordinary concerns, an invincible determination, and a knightly courage. The Spaniards under Cortez and Pizarro did not manifest more bravery in slaying the Mexicans and Peruvians for the sake of their gold than these men showed in fighting the Pequods for the glory of God and for the safety of His church. After their victory, they immediately began to legislate for their recent foes, — to forbid the selling of strong liquors to them, to preserve their grounds from trespass, and to send missionaries to declare unto them the glad tidings of the gospel of peace. The opinions, fashions; and laws of the Puritan colonists have passed away almost as completely as the Puritans themselves. But few stones remain, with a decipherable inscription, to mark the spots where they are buried. But a monument exists to them in the hearts of their descendants; and the admiration and respect which are due to their motives and characters are renewed and strengthened by the publication of every faithful record of their doings.

ART. III. — 1. *Introduction to Meteorology.* By DAVID PURDIE THOMPSON, M. D., Grad. Univ. Edin. Edinburgh and London: William Blackwood and Sons. 1849. 8vo.

2. *A Complete Course of Meteorology.* By L. F. KAEMPTZ, Professor of Physics at the University of Halle. *With Notes*, by CH. MARTINS, Supernumerary Professor of Natural History to the Faculty of Medicine, Paris; and an *Appendix, containing the Graphic Representation of the Numerical Tables.* By L. LALANNE, Civil Engineer. *Translated, with Notes and Additions*, by C. V. WALKER, of the Electrical Society. Illustrated with 15 Plates. London: Hippolite Bailliére. 1845.

ALTHOUGH the claim of meteorology to be admitted to the rank of an exact and well-digested science is recent, still

there has never, probably, been a period or a country in which the aqueous, igneous, and electrical meteors of the air, both in their ordinary and in their more startling phases, have not been observed by curious and thoughtful men : and in which these observations have not led, if not to the discovery of laws describing the atmospheric relations of our planet to light, heat, or electricity, at least to speculations upon the phenomena observed and prognostications from them. These atmospheric changes, conducted by the agency of the various physical forces which play their part at the earth's surface, are well calculated to arrest the attention of an intellectual race, none the less in their orderly diurnal, monthly, and yearly march than in their grand revolutionary strides ; more than any other natural phenomena, they come directly home to the comfort and spirits and employment of every man, touching his property, affecting his safety, altering his plans for the day ; and by familiarity, unlike most other things, they lose nothing of their interest or their mystery.

The writings of the more civilized nations of antiquity abound in observations, allusions, and deductions relating to meteorology ; and travellers, it is asserted, visit no people where an effort to construct this difficult science is not apparent. To know the development that was attained, and the difficulties which arrested all further progress, among the ancients, we must go to the most scientific writers of the most cultivated nations, — to Aristotle among the Greeks, and Pliny among the Romans. Aristotle's treatise "*On Meteors*" is more voluminous than most English works on meteorology at the present day. Winds, rains, snow, hail, dew, frost, rainbows, halos, thunder and lightning, if not satisfactorily explained, are at least carefully and accurately described. Take the following passage from Book III., Chap. II. on the halo and rainbow.

" But, in the first place, it is necessary to assume the properties and the accidents pertaining to each of them. Of the halo, therefore, the whole circle is frequently seen, and is formed about the sun and moon, and the most splendid of the stars. And farther still, it is no less seen by night than by day, and about noon than in the afternoon ; but it is less seen in the morning and about sunset. Of the rainbow, however, there is never a complete circle, nor any section greater than that of a semi-circle ; and when the

sun sets and rises, the rainbow is the greatest arch of the smallest circle ; but when he is more elevated, it is a less arch of a greater circle. After the autumnal equinox, also, in the shorter days, it exists every hour of the day, but in summer, it does not exist about noon. Nor are there more than two rainbows at the same time. But of these, each is of a triple color, and they have the same colors and are equal to each other in number. The colors, however, which are in the exterior rainbow, are more obscure, and have a contrary position. For the inward rainbow has its first periphery, which is the greatest, of a light red color ; but the exterior has its smallest periphery, but which is nearest to this, and analogous to the others, of this color. These colors, too, are nearly alone these which painters are unable to make. For they mingle some of these colors ; but they cannot by mingling produce the light red, the green, and violet color of the rainbow. But the color which is between the light red and the green is frequently seen to be yellow."

Great are the physical convulsions which have agitated this planet ; manifold are the permutations through which the same identical material has passed. As the great prince of philosophers himself knew and reported, rivers are generated in one place and fail in another ; "where there was land, sea is produced ; and where there is now sea, there will again be land." According to Ammonius, the land has become sea for five stadia about Heraclea and Canopus, as is evident from habitations which still remain in the middle sea, and which resemble islands. The laws of nature, however, have survived all these vicissitudes of matter, and still abide the invariable expression of the unalterable wisdom of the Creator. The rainbow which hung over Greece more than two thousand years ago, and which Aristotle has so faithfully portrayed, is no other than the rainbow of the last summer in our own New England. The impression of this contrast between the brevity of individual life and experience, and the long periods allotted to the plan of nature, is deepened by the following passage from Aristotle, in which he refers to a still older antiquity, just as we refer to the Greeks and Romans.

"And the rainbow, indeed, is formed in the day ; but in the night, as the ancients fancied, it is not formed from the moon. They were of this opinion, however, because the rainbow is rarely seen in the night, and of this they were ignorant. For it is produced in the night, but seldom. But the reason is, that in dark-

ness colors are concealed, and it is necessary that there should be a coincidence of many other particulars, and that all these should take place in one day of the month. For it must necessarily happen in the full moon, and then when the moon is either rising or setting. Hence we have only known it to happen twice in the last fifty years."

Many other passages might be quoted to show not only the permanency of the forces of nature, but the fidelity with which they were studied by some of the classical writers. The conversion of water into vapor under the impulse of the solar rays, and its relapse into the liquid state when the heat deserted it, in some one of the various forms of rain, snow, hail, dew, or frost; the division of the winds into dry and moist; the ominous clatter that precedes a hail-storm, and the size and shape of hail-stones; the seasons of the year and the geographical latitudes in which hail abounds, — all these facts are clearly painted from life, and the processes which they involve are interpreted as intelligibly as could be expected at a time when such material links in the chain of cause and effect as the doctrine of latent heat, and the electrical and magnetic forces, were wholly unknown. Aristotle, speaking of lightning, says it "is produced after the percussion, and posterior to the thunder; though it appears to be prior to it, because the sight apprehends its object prior to the hearing. This is evident from the rowing of three-ranked galleys; for when the sailors again elevate their oars, the first sound of the rowing reaches our ears."

So far as we can judge from Pliny's *Natural History*, the only work which has reached us from the vast materials collected by that laborious and learned compiler, no important additions had been made in his day to the scientific treasures which Greece had poured, with the rest of her civilization, into the Roman empire. Some of his chapters, particularly that on the rainbow, bear internal marks of the source from which they were drawn. In the writings of this first martyr of science, as he has been called, we notice, as in Aristotle, frequent passages which exhibit close and accurate observation. Speaking of thunder and lightning, Pliny says: — "Hereupon it is that every thing is shaken and blasted ere it be smitten: neither is any man stricken who either saw the lightning before, or heard the thunder clap." In another place, Pliny describes

in graphic language the water-spout. "There riseth also upon the sea a dark mist, resembling a monstrous beast, and this is ever a terrible cloud to sailors. Another, likewise called a column or pillar, when the humor and water engendered are so thick and stiff congealed, that it standeth compact of itself. Of the same sort, also, is that cloud which draweth water to it, as it were into a long pipe." In this early encyclopedia of science, superstition and a love of the marvellous have displaced in some degree the severity and dignity which stamp the pages of Aristotle. While some of the Greek philosophers were ashamed of contributing to that science which was simply useful to their fellow men, Pliny is not too proud to say, "Therefore, seeing there be so many thousand poor sailors that hazard themselves on the seas, I will treat of the winds more curiously and exquisitely than perhaps beseems the present work that is begun." How much the poor sailors profited by this utilitarian spirit may be inferred from the advice which Pliny gives them for escaping whirl-puffs or typhoons, namely, to "cast vinegar out against them as they came, which is of nature most cold." Other facts of the same spurious character, and doubtful maxims built upon them, Pliny allows to have a place in his *Natural History*. We feel the more lenient towards such folly when we remember that some of these traditions were not outgrown even by our own admired Franklin, and by the scientific progress of which he was the exponent. Pliny describes that sort of lightning which empties casks of their contents without disturbing the hoops, sides, or heads. "Gold, copper, and silver money is melted in the bags, and yet the very bags no whit scorched, no, nor the wax of the seal scorched and defaced, or put out of order. Martia, a noble lady of Rome, being great with child, was struck with lightning, the child she went withal was killed within her, and she, without any harm at all, lived still."

But the most patient observation, without experiments, without delicate instruments, without an intimate knowledge of the principles of all the physical sciences, and without a clear conception of the fundamental laws of equilibrium and motion, could carry men no further than to the natural history of the weather. Physical facts were known to the ancients, and the knowledge was applied to the practical pursuits of life ;

but most of the great physical laws were either wholly unknown, or imperfectly apprehended. "If," says Aristotle, "any one make water very salt by mingling salt with it, eggs will swim in it, though they are full." Thus, ships which are full freighted at sea will be too heavily laden when they enter the fresh water of a river. The infirmity of ancient science appears most clearly in the conception which it had gained of mechanical principles, especially of the laws of dynamics. Aristotle denied that the wind was air in motion; he taught that the same thing which on the earth is wind, in the earth is an earthquake, and in the clouds is thunder. So far is Pliny from having a just conception of the atmosphere as a highly elastic fluid, pressing on all sides, ready instantly to leap into a new equilibrium when it is disturbed, that he discusses seriously the question how many different winds there may be, and decides in favor of eight, two for each quarter of the heaven. If the laws of mechanics had not yet been mastered in their application to simple attractive and repulsive forces, acting on a wide and open theatre, what progress could be expected in the mechanical development of those delicate forces, which are not only invisible themselves, as all other forces are, whether spiritual or physical, but which in our human conceptions of them seem allied to spiritual forces; inasmuch as the amplitudes of the motions which they cause are so small, and the material medium through which they operate is so subtle, as to escape the direct grasp of the human senses, even when exalted by the wonderful contrivances of art? What wonder, therefore, that Aristotle, Epicurus, and Lucretius, when they considered the eye and the incessant intercourse which it holds, by means of the attenuated lines of light, with the whole visible creation, in the earth and in the skies, the source of so much joy to the lowest orders of the animal kingdom, the instrument of such profound science to man himself, should have summoned to their aid the conception, not of radiations proceeding directly or by reflection from the visible object, and painting its picture on the prepared retina, but of emanations going forth from the eye to seize upon its object; and should have spoken of the reflection of the sight as we now speak of the reflection of rays of light.

The tedious centuries which bridge over the long interval

between the decay of ancient science and the revival of modern science gave no new insight into meteorology, nor added much to its storehouse of facts. During this dismal period, astronomy was subservient to astrology, chemistry to alchemy, and meteorology to the art of prognostication. The reappearance of meteorology, clothed in the simple garb of modest science, is but of yesterday. While astronomy is pursuing her luminous path through the skies with the vigor of a giant, while the chemical and physical sciences have been made transparent by the discovery of harmonious laws, while natural history is busy collecting, recording, and classifying, seeking and finding the living even among the dead, meteorology is yet in its infancy, an infancy as abundant in weakness as it is in promise. Meteorology has not fallen behind the other sciences from neglect or from want of zeal, or numbers even, on the part of its cultivators ; it occupies this position from a physical necessity, and deserves reproach for it no more than the rear-guard of an army for standing in its lot. Meteorology must follow behind the physical sciences ; it can never lead them.

“ The number of observations,” says Kaempts, “ on the modifications of the atmosphere is doubtless considerable ; but they are, at the same time *observations*, in the most restricted sense of that word. We observe the phenomenon presented to us, but we cannot modify and vary it at pleasure ; we cannot even reproduce it at will. In a word, we cannot have recourse to *experiment*. Our means and our powers are much too limited to give us the power of producing the least changes in the atmosphere. We are hence compelled to register facts ; and, as W. Herschell has well observed, we resemble a man who hears now and then a few fragments of a long history, related at distant intervals by a prosy and unmethodical narrator. In recalling to mind what has gone before, he may occasionally connect past with present events ; but a host of circumstances omitted or forgotten, and the want of connection, prevent his obtaining possession of the entire story. Were we allowed to interrupt the narrator, and ask him to explain the apparent contradictions, or to clear up any doubts on obscure points, then might we hope to arrive at a general view. The questions that we would address to nature are the very experiments of which we are now deprived in the science of atmospheric modifications.”

This is a great embarrassment to meteorology, but it is not

the greatest. Otherwise astronomy, now the foremost among the sciences, would fall behind them all. We cannot tamper with the celestial mechanism; we can only observe the fixed stars and the roaming planets, through vast distances made easy to the telescope; and of the most eccentric, as the comets, we only catch a glimpse now and then. Still, geometry follows the absentee of a century with infallible precision, and, when it returns, assigns the place and the time with an accuracy which astonishes the world.

Meteorology, in its highest sense, is not a department of natural history, nor a single physical science; but the sum and substance of all the physical sciences. It is the application of all the physical sciences to a grand organic problem, — to the problem of life and growth; not indeed to the highest form of life, to spiritual life, nor to that lower kind of life which we recognize in the movements of animals, but to the problem of life in its most material, most tangible, most simple exhibition; to the life and growth which are controlled by well known physical and chemical forces, and are independent of those peculiar vital forces, which are superadded to mere physical forces when we ascend to the higher forms of life. Each planet of the solar system is a unit, an indivisible, organized unit. If a crystal is broken to pieces, each fragment, however small, retains in perfection the crystalline form and beauty, and all the curious molecular machinery which enables it to polarize the sunbeam, and extract its beautiful colors. But the rending of a planet is like the cutting off a hand or leg, or otherwise maiming the animal frame. A fanciful hypothesis was once promulgated by authority which is not likely to be soon discarded from our text books; namely, that a considerable planet revolved between Mars and Jupiter, which, by some mishap, was shattered in pieces, and that the larger fragments, outcasts from the zodiac, are occasionally discovered as telescopic planets. Supposing this theory to be hampered by no mechanical impossibility; supposing that the motions of the eight small planets could be traced back by the geometer to that remarkable conjunction when they were all together ready to pursue a common orbit, if the force which scattered them is withdrawn, what reason is there to believe that the most substantial of these bodies, four of which have by their recent discovery given as brilliant a close to the present half century,

as the other four had done to its commencement, is gifted in all respects as the earth or any other undisturbed planet; or is capable of furnishing a fit home for the organized creation without being subjected again to that long process of heating and cooling by which the various chemical and physical forces are set free in proper proportions, and the planet is tempered to the wants of the beings which are to live upon it. When we speak of each planet as an organized unit, moulded by time and not struck out at a blow, deriving its most valuable qualities from the relations of its parts and not from the inseparable properties of its atoms, it will not be understood that all change and interchange of these parts is excluded. Such stagnation is the opposite of life and growth. As the material of the human body is gradually renewed every few years, so the particles of the earth exchange places with one another; the solid rock crumbles, is washed down and converted into sediment, while the secretions of zoöphytes are tracing the foundations of islands, if not of continents. The view we have presented excludes none of those changes called growth, but only such as amount to a total dismemberment.

Where now, we ask, is the most vital part of this organized planet, the earth; where are its most precious functions; where are the breathing pores and arteries through which its circulations are conducted; where is the great heart which animates it, unless in the fluid water and air, and the motions which belong to them? Though the ocean is not so deep relatively as the dew upon the pyramid, though the atmosphere covers the earth more slightly than the thinnest veil of muslin wraps some statue of angelic size, what a desert, what a decayed body, would the earth become, if the atmosphere were stripped off and the ocean were drained? Where would be its animal and vegetable life? Or if an organization is possible in which the presence of oxygen is not required, where would be the physical life of the earth itself? Where would be the winds, and the clouds, the dew, the frost, the snow, and the rain? Where the rainbow, the aurora, and the morning and evening glories? How sombre and dead would even the sun, moon, and stars appear, if their light was not mellowed and refined by its passage through the atmosphere? How silent and cheerless, how deaf and dumb, would the whole earth be, how useless the voice and the ear, if the hum of insects, the song

of birds, and the peerless tones of the human voice died instantly on the spot where they originated, instead of being caught up by the omnipresent air, and carried in a thousand directions to charm the senses and delight the hearts of all living things? Without the atmosphere, in what new and extraordinary way would an equalization be effected between the superfluous heat of the equator and the excessive cold of polar regions? How would the carbonic acid be prevented from gaining a dangerous ascendancy at the north during the long winter, if it were not exchanged, through the medium of the atmosphere, with the superabundant oxygen generated at the equator by its luxurious vegetation?

The ancients, having clearer conceptions of animal forces and motion than of such as were mechanical, assigned to each planet a tutelar divinity, by which all its motions were produced. The bold and imaginative Kepler, cramped by the same poverty of mechanical ideas, made the planets themselves real animals,—huge monsters swimming in space, and puffing, sweating, and spouting, and thus creating volcanoes, tempests, and earthquakes. Modern astronomy has dispensed with all tutelary divinities except the single law of gravitation; and this law, acting conjointly with the chemical and physical laws, has superseded Kepler's personification of the meteorological phenomena. When we speak of the earth, particularly in its atmospheric relations, as organized, we do not mean that it resembles man or any other animal, nor do we mean that it is animated by the presence of all those living things which find their home and sustenance upon it. We refer to the development, growth, complexity of relations, and reciprocity of services between its different parts under the agency of purely material forces, which remind us of the higher forms of life in which the chemical and physical forces are subordinate to vital and spiritual influences; of which we know little except their reality and power. With this caution, let science delight to study the growth of milky ways, of systems and individual planets. Without compromising her severity she may fancy the solid mountains to be the backbone of the earth, as the atmosphere is the vital part, the heart of the organized mass, whose pulsations animate the whole. Though, as we have said, the atmosphere comprises but an insignificant fraction of the whole material of the planet, still the bulk and weight even

of the atmosphere are vast beyond comparison with any thing else we commonly call an animal ; and the forces concealed in it have no common unit with those which belong to humbler organizations. Is not the atmosphere the depository of those grand forces of heat and electricity, in their latent form, a single spark of which is sufficient to illuminate the eye and animate the frame of the largest monsters that live upon the earth ? Though the atmosphere is thinner relatively than the film of varnish upon a common globe, its collected weight equals five thousand millions of millions of tons. Equally disproportioned are the rapid circulations in an animal, which are completed once in every few minutes, to the vast currents of wind and moisture which encircle the earth from the equator to the poles, and from the poles back again to the equator. The moon performs a whole revolution round the earth, while a single drop is flowing from the head waters of the Ganges down the eighteen hundred miles which separate it from the ocean. The earth, therefore, may go round in its large orbit, before a drop of water shall have made the tour of our planet from the spot in the ocean whence it ascended in mist or vapor back to the same spot again. If the circulation of a single particle occupies so much time, astronomy must be taxed for her largest secular periods to express the secular disturbances of the atmosphere. If, as Lalande has calculated, the conjunction of the six chief planets in the same spot of the heavens will take place only once in seventeen millions of millions of years, what finite mind can comprehend the periodicity of many atmospheric changes ? to what standard reduce the shortest time for ringing all the changes upon the atmospheric elements ? According to Pliny, some ancient astronomers, whose conceptions of the celestial mechanism bear a closer resemblance to an orrery than to the great heaven of heavens, supposed “ that, after the end of every fourth year, not only all winds, but other tempests and constitutions also of the weather, return again to the same course as before.”

Meteorology must instruct us in the physiology of the earth, as geology has chalked out its anatomical structure. When we call the movements of the atmosphere organized, we do not deny that they are mechanical, but declare rather the complexity and delicacy of the machine. These atmospheric movements present to the mind a mechanical problem for which

the celestial mechanics will hardly furnish the alphabet. In its presence, the mind even of a Newton or Laplace seems impotent. What formulæ shall express the changes of the wind, the alternations of heat and cold, of dryness and moisture, of a heavy and a light atmosphere; over which presides not the simple force of gravitation alone, but elasticity, heat, electricity, magnetism, hold a divided empire? Whoever is accustomed to contemplate nature under its physical and mathematical aspect may readily believe, that even the fickle weather stands out before the mind of the Creator in all the simplicity of the conic sections, and conforms to algebraical rules as simple, perhaps, as the celebrated laws of Kepler. Well may science humble herself at this moment of her proudest triumph, to feel how circumscribed her range, how clipped her wings, how dim her vision, how incompetent to grapple with some of the most familiar phenomena of the outward universe. Though meteorology, as at present developed, falls exceedingly short of the high destiny which in imagination we have seen prefigured for it, it has already assumed the dignity of a physical science. This improvement is to be referred, partly, to the greater skill now expended in the construction of meteorological instruments; partly, to systematic and judicious plans of observation; partly, to the superior education and scientific acquirements of those who cultivate the science; but much more, we are persuaded, to the progress which the last fifty years have witnessed in those physical sciences most akin to meteorology. More labor has been expended in meteorology, and to less profit, perhaps, than in all the other physical sciences. Thousands of observations on the thermometer and the barometer have been made by incompetent observers, who brought no thought to their work, but went daily to their instruments from habit, as some men go to the post-office. Good observers have wasted their energies on poor instruments, unworthy of confidence and discreditable to science. Observations, which if reduced and printed, would help to light up the dark ways of meteorology, lie entombed in the manuscripts in which they were originally entered, a dead loss to science. The most liberal endowments, the highest order of artistic skill, the best scientific talent, have been lavished on astronomical observatories, while meteorology has been left to take its chance with amateur observers; as if it were too simple to require patron-

age, or too unimportant to deserve it. Even within the walls of the astronomical observatory, made sacred to science, meteorology was regarded as an interloper which might trespass on the funds of the institution, or distract the zeal of observers. Captain Smyth has given us, in his "Celestial Cycle," the following anecdote in relation to Lalande and the observatory over which he presided.

In his astronomical *exposé* for 1801, Lalande says: "Well-placed weathercocks are very rare at Paris. There is none at the observatory, though I requested one on being appointed director; and I have thanked, in the name of all observers, citizen Bois, tinman, who, having built a house on the Quai des Augustins, has erected there a lofty and very movable weathercock, with letters indicating the four cardinal points, which will be on a line with a meridian I have marked out on the quay. Astronomers, when they go to the Institute or Board of Longitude, will have an opportunity of seeing conveniently the direction of the wind; and the same advantage will be enjoyed by the inhabitants of that vast quay, of the Louvre, and the surrounding houses." This indifference shown to meteorology by the cultivated, who should have known how to prize it, left it in the hands of the illiterate, and served to perpetuate, if it did not produce, its degradation. It was only a few years since, says Captain Smyth, that the editors of the celebrated *Moore's Almanac* attempted to discard the column containing the moon's supposed influence on the legs, arms, nose, eyes, &c. In order to feel the public, a small edition of only one hundred thousand copies was issued at first. But the omission was detected; the whole edition returned, upon their hands and they were forced to print another, with the favorite column restored.

We rejoice to believe that a better day has already dawned on meteorology; that the practical and scientific importance of the subject is realized; that accomplished observers are demanded for it, who not only know how to observe, but what to observe, and are able, by a happy selection, to take hold of the salient points in the science, and extricate themselves from its overwhelming mass of details. The whole scientific world is impressed with the importance of the subject; and competent observers are devoting their energies exclusively to special departments even of the general science of meteorology. If the

expectations of meteorologists are less ambitious than formerly, they are more likely now to be realized. They are not able, and they do not aspire, to "predict or even approximate to a prediction, whether, on the morrow, the sun shall shine, or the rain fall, or the wind blow, or the lightning descend. The wind bloweth where it listeth; we hear the sound thereof, but cannot tell whence it cometh, or whither it goeth." They aim, first of all, to investigate the most general movements of the atmosphere, eliminating what might dazzle as well as perplex the casual observer, because it is local and accidental. Hence the importance of knowing where to observe, as well as what to observe, and how to observe. A single year of good observations made at a critical place will be more fruitful than fifty years of observation elsewhere. Hence the meteorologist must sometimes leave his home and country, and plant himself in some lonely island, on some height almost inaccessible, in places which have no charm to the heart of man except that of science. Individuals can always be found ready for the sacrifice, if the necessary means are provided. The hardy navigators, who for scientific objects have wintered around the maximum of cold, if not at the geographical poles; geographers, whose labors have expanded into every latitude and longitude; meteorologists, who have pillowed their heads on glaciers, the sides of volcanoes, or upon the eternal snows; astronomers, whom their beloved science has driven into a southern exile, — these men, and the adventures of which they are the heroes, are a sufficient assurance that devoted observers will be ever ready to go where the laurels of true science are to be won.

The general principles of physical science can be investigated anywhere, by the solitary student, if he take care to make himself and keep himself familiar with the labors of others in similar provinces of science. But the application of these general principles to the physical condition of the atmosphere cannot be studied anywhere; neither can they be profitably pursued alone. The two hundred thousand observations made by Dalton, during a period of fifty years, the fifty-four thousand seven hundred and fifty observations taken at Stockholm during an equal term of years, are not available for the settlement of preliminary questions in meteorology, for want of comparative observations in other parts of the earth. The associated action which marks the present movement in behalf

of meteorology is not a new idea ; but it has never till recently been practicable on a large scale. The meteorological society of the Palatinate, which commenced its operations in 1780, under whose auspices, and with whose instruments, a series of observations was made at Cambridge, since published in the *Memoirs of the American Academy*, lasted only ten years. The distracted state of Europe afterwards, the wars and the alienation of feeling which lasted even when peace had returned, prevented a renewal of the effort. At length, a variety of causes coöperated in consummating what had so long been desired. The startling display of meteors in 1833, the return of another epoch of auroral exhibitions, the residence of Herschel at the Cape of Good Hope, the influence of the British Association and other scientific confederacies, the mighty voices of Gauss and Humboldt, heard and respected over the whole world, led to decisive action. The independent observatories that have already been erected for meteorological and magnetic purposes rival in number, and the excellence of their appointments, both of observers and instruments, the astronomical observatories. This would not have been possible in so short a period, had the buildings or the instruments used in meteorology compared in cost with the grand instruments which adorn the astronomical observatory. The latter, also, is not left dependent on a neighbor's weathercock for the direction of the wind, but keeps one eye open on the physical changes in the earth's atmosphere, while the other is lifted to the stars. The situation of the special meteorological observatories has not been abandoned to accident or fancy ; but they have been distributed over the earth, as the light-houses are posted upon the coast, in barren, bleak, and desolate places, clustering, if anywhere, round the spots of greatest danger. The part which America has played in this meteorological movement has been a subordinate one. The British government commenced a meteorological observatory at Toronto in 1840, which has been continued to the present time, and been the centre of considerable operations in British America. Establishments of a similar character have been temporarily sustained by private bounty at several places in the United States.

Among other ways in which the Smithsonian Institution at Washington is laboring for the advancement of science, it has

assumed recently the responsibility of superintending and publishing the meteorological observations made in the United States, and of furnishing instruments for places of eminent value in meteorology. New York has taken the lead among the States in helping forward this science, by providing sets of comparable instruments for thirty stations, carefully selected on two lines of different level extending through the State. The American Academy of Arts and Sciences at Boston invited the attention of the legislature of Massachusetts to the same subject, at their recent session, and recommended the appropriation of \$1200 to furnish instruments for twelve stations in this State, which was promptly granted by the legislature. It is expected that individuals will be induced, here and elsewhere, to undertake the observations, from an interest in the subject more than by the trifling compensation that can be afforded. When we consider the vast geographical extent of the United States, its importance in a meteorological view, as containing an area wide enough to exhibit grand atmospheric movements, the insignificance of the outlay compared with the advantages to be realized or with the cost of most other operations, practical or scientific, it is believed that the other States will not be slow to emulate the example of New York and Massachusetts. The State of its abundance should give a little for the promotion of a desirable scientific enterprise, when men of science, of their penury, contribute all they possess, namely, their time and labor. At the request of the Secretary of the Smithsonian Institution, Professor Guyot of Cambridge has prepared, and is on the point of publishing, complete instructions to meteorological observers; and it cannot be too strongly urged on all who, in any part of the country, desire to coöperate for the advancement of meteorology, that they should adopt the instruments and the methods of observing which Mr. Guyot may recommend. A uniform system of meteorological observations, extensively adopted all over this vast country, would be an example to the world, and the best assurance which could be given, that science was prepared to cope with some of the difficult problems relating to the organic structure of our planet.

While so much has been done, within a few years, and is still doing, in a public way, towards laying an ample and stable foundation for meteorology, zealous observers have been sedu-

lously pursuing special departments of the subject with remarkable success. One class of observers has watched with successful pertinacity the falling stars; another has been no less assiduous in studying electrical meteors. One class, at whose head stand Dove and Kaempts, has perfected the theory of the winds, and demonstrated their paramount influence on other atmospheric changes; while another class, in whose ranks Reid and our own countrymen Redfield and Espy occupy the first place, have aspired, and not without reason, to prescribe laws even to the fury of the storm. At Madras, Bermuda, and the Isle of Mauritius, are established what may be called storm-observatories; where the annals of the tropical hurricanes are written down from the logs of ships which encountered them, or from the records of the observatory; where the premonitory signs of destructive whirlwinds are discovered by induction, and telegraphed on their reappearance to the shipping in the harbors.

An exponent of the present activity in meteorological inquiry is the increased abundance and excellence of the literature on the subject. We need only refer to the quartos of meteorological observations periodically sent forth from the astronomical and the meteorological observatories; to Arago's elegant report on thunder and lightning, from which British authors have so largely and unceremoniously drawn; to Peltier's book on waterspouts; to Espy's *Philosophy of Storms*; to the two substantial volumes which Lieut. Col. Reid has published at different times on the same subject; to the numerous valuable papers of Redfield in *Silliman's Journal* and elsewhere, and the equally numerous and no less valuable memoirs of Piddington in the *Journal of the Asiatic Society*; to the practical application which Mr. Piddington has made of the theory of storms, (teaching the navigator to profit by them,) and which he has given in his recent publication "*The sailor's horn-book for the law of storms in all parts of the world.*" Finally, we may point to the "*Meteorologische Untersuchungen*" by Dove, and the various papers which this illustrious physicist has published in the *Memoirs of the Berlin Academy*; to the "*Lehrbuch der Meteorologie*," in three volumes, by Kaempts, which appeared during the interval between 1831 and 1836; and to the more recent works on the same subject which are named at the head of this article; one

of which is from the same meteorologist to whom we have just referred. The splendidly illustrated report, published by order of the French government, on the auroral observations made by Lottin and the other members of the French commission of the North, should not be omitted in this rapid recital of meteorological literature.

The "Introduction to Meteorology" by Thompson, and the "Complete Course of Meteorology" by Kaempts, are elaborate and classical treatises upon the general science so far as it is yet developed. A glance at the contents of these works, and those of a similar aim, published in the early part of the century, will indicate the stride which the science has taken. Marvellous phenomena, or, as Kaempts styles them, problematic phenomena, such as showers of sulphur, corn, blood, flesh, fish, meteoric stones; also, prognostications of the weather; topics which fill a considerable portion of Forster's book on atmospheric phenomena, shrink, in the works before us, into the compass of a few pages. While Professor of Physics at Halle, Kaempts made observations on the barometer, thermometer, and hygrometer for ten consecutive years. He made his home on the Righi in Switzerland, 5938 feet above the level of the sea, from May 27 to June 24, 1832; on the Faulhorn, 8766 feet above the sea, from the 11th of September to 5th of October. He passed more than a month of the next year on the same elevated spots. In 1837, he studied the atmospherical phenomena of the North of Europe at Deep on the Baltic, and at this present time he is a professor in the University at Dorpat. Mr. Thompson has not favored the reader with any preface to his work; we have, therefore, no positive knowledge of his qualifications other than the character of the book itself, and that is sufficient. Although the topics discussed in these works are the same, and the order of arrangement not dissimilar, neither appears as a transcript of the other; each has the merit and all the value of an independent work. The quality of mind of the two writers is very different. Kaempts is an able observer; Thompson a learned and elegant compiler. Kaempts has treated the subject profoundly and originally; Thompson has made it attractive. Kaempts has been so preoccupied with those investigations into the primary laws of meteorology, which he has helped to elucidate, as to make of too little importance other

inquiries, not so fundamental, perhaps, and, not yet certainly, susceptible of the same precision, but none the less important. The labors of Espy are not mentioned, unless by the French translator in a note; and the theories of Redfield and Reid in regard to the philosophy of storms, which are too plausible and too directly associated with Dove's general view of the winds to be summarily dismissed, are not even named. Mr. Thompson's work shows familiarity with the whole field of meteorology and all its historical treasures; it is, without doubt, the ripened fruit of his accumulated labors. Kaemptsz's book may be the best guide to the scientific meteorologist, but Thompson's will be full as interesting to the amateur. We must avoid, however, painting these contrasts in too strong a light. Either book may be read with profit by all; and each is an important acquisition to meteorological literature. Kaemptsz's work is, to use his own phrase, rendered complete by the circumstance that he treats at some length, and in an elementary way, of the various physical laws which are applied in meteorology.

We have spoken of the plan of the two works as not unlike. This comes partly of necessity. The human mind, unable to grapple with a subject so complex as meteorology, in all its generality, seeks relief by contemplating it in detached parts. First of all, we might naturally study the relations of the atmosphere to the chemical forces. This leads us to consider the chemical properties of the atmospheric ingredients, and the harmony which must exist between them and animal and vegetable life. This preliminary step is deliberately taken by Thompson; but our other author, as if anxious to lose no time in getting at his subject, jumps at once, after three pages of introduction, to the physical relations of the atmosphere. Afterwards, however, he briefly alludes to the chemical properties of the atmospheric gases.

First among the physical conditions of the atmosphere is its relation to the dominant force of gravity. This leads us to consider the weight of the atmosphere, as measured by the barometer. The struggle between the weight of the air and its elasticity, ending in its assuming a figure of equilibrium, suggests the bulk and form of the atmosphere, the law of density which it follows at different heights above the sea, as determined by the barometer or the duration of twilight, with

the assistance of acknowledged principles in geometry and mechanics. In the agitations of the atmosphere, gravity appears as the principal leveller, the instrument of order and stability, as heat is the great disturber. All structures, organic and inorganic, almost all chemical and physical processes, and many of the most homely arrangements of civilized society are intimately related to the weight of the atmosphere, and are seriously affected by any change in that weight. It is well known that the boiling point of water and other liquids, or the temperature at which they pass suddenly into the state of vapor, diminishes as the atmospheric pressure decreases. Mr. Thompson repeats a pleasant anecdote, told by Mr. Darwin of the *Beagle*, who, in 1835, crossed the Andes, which shows that the subduing influence of cooking belongs to the heat and not to the fact of boiling. "Our potatoes," says Mr. Darwin, "after remaining for some hours in the boiling water, were nearly as hard as ever. The pot was left on the fire all night, and next morning it was boiled again; but yet the potatoes were not cooked. I found out this by overhearing my two companions discussing the cause; they had come to the simple conclusion, that the potatoes were bewitched, or that the pot, which was a new one, did not choose to boil them." Thompson adds that "on the Nonewara mountain, Baron Hügel had much difficulty in melting ice in consequence of its passing off in vapor without dissolving; at last he found the boiling point of water to be 188° ." On the Andes, the Peak of Teneriffe, Mont Blanc, and at the Hospice de St. Bernard, water boils at so low a temperature that the heat is not sufficient to soften animal fibre. Hence, the peasants are provided with what may be called a high-pressure pot, protected by a safety-valve. In 1817, Rev. F. J. H. Wollaston invented a thermometer, which indicated the one thousandth part of a degree of Fahrenheit. As the boiling point of water sunk through several divisions on the scale of this instrument, if it was raised from the floor to a table, Wollaston thought that it would supersede the barometer for measuring heights, especially when regard was had to its strength and portableness. Its manufacture for this purpose has recently been revived in Europe.

The same diminution of atmospheric pressure, which allows water to boil with less heat, makes it difficult to obtain that

heat. Travellers, since the thirteenth century, have noticed that fires kindled on mountains burned less freely than on the plain below. An equal impediment exists to that slow combustion which accompanies respiration. The whole animal creation sympathizes with the inconvenience, and sometimes pain, which are endured by those who have entered into the rarefied strata of the atmosphere. Mr. Thompson agreeably illustrates this point by telling the story of Mr. Lyell, "that the English greyhounds, taken out for the Real del Monte company in Mexico, when hunting at an altitude of 9000 feet, where the barometer does not rise above 19 inches, were unable to bear the fatigues of the chase, and fell down gasping in such an attenuated atmosphere; but, as if nature would provide for the altered condition of the race, the whelps felt no inconvenience from its rarity." The pliability of the human body, its power of adapting itself to new physical circumstances, is wonderful in this as in other things. The whole range of the barometer at the earth's surface, which is sometimes completed in the short space of a few weeks, as at Cambridge during the last winter, corresponds to a change in the pressure which surrounds the human body to the amount of more than one ton. In 1804, Gay Lussac ascended in a balloon 23,000 feet; in 1838, Green and Rush rose in the same way to a height of 27,136 feet. Lussac's barometer stood at 13.95 inches,* and the pressure on the body was diminished by more than seven tons. Where no effort is necessary, as in these cases, this extraordinary change in physical circumstances produces less effect than in climbing mountains; where, though the change is less sudden, a few steps suffice to exhaust the strength. Experiment shows that birds, whose home is in the deep sky, still feel the exhaustion in the receiver much more quickly than cold-blooded animals, as fishes.

We pass to a brief consideration of the atmosphere in its relation to heat. Here we enter a rich province of meteorology. Heat is the prime mover in the atmospheric mechanism. Among the physical relations of the atmosphere, those to heat are the most momentous. We are here led to examine the position in which the earth stands to the sun, the great source of

* Mr. Thompson's remark (page 42,) "that the weight of atmosphere which Gay Lussac then sustained was only about a fifth of that borne at the surface of the earth" is incorrect. It was about two fifths.

calorific radiation ; and the degree to which the fund of heat thus derived is modified by the temperature of the spaces through which the earth, along with the rest of the solar system, may be passing, and by the internal heat of the earth, which is continually renewed by the solidification of liquid matter within the crust and by the release of its latent heat. Under the potent wand of the solar beam, the earth's waters ascend in the state of vapor, an invisible mysterious state, afterwards to reappear in the shape of the white cumulus, the frowning nimbus, or the delicate cirrus ; or to paint on the sky the beautiful lines of the mackerel's back. So incessant, so irresistible, is the power of these slender rays from the sun, that the united strength of the human family is insufficient to protect a single sea from their devastations. Mr. Leslie has computed that 52,120 million cubic feet of water, each of which weighs $62\frac{1}{2}$ pounds, are carried up 18,000 feet into the atmosphere every minute. The power of the sun in producing evaporation equals that of eighty millions of millions of men, or 200,000 times the accumulated toil of the working population of the earth ; and it is eighty times as great as the power which it exerts together with the moon in producing the tides. Acquiring in its passage from the liquid to the gaseous state a capacity for heat which exceeds that which accompanies a similar physical change in any other fluid, with what admirable economy does this enormous mass of vapor garner up the prodigal rays of a tropical sun and of a summer's day, rescue them from the incessant radiation which wastes all free heat, and transport them in its delicate folds, on the wings of the winds, to the uttermost parts of the earth, to bestow them on seasons and zones which fare less sumptuously from the sun's bounty. There and then, it descends as dew, (called star-spit by the natives of Orinoco,) or frost, rain, hail, sleet, or in some one of the ninety beautiful forms of the snow, to gladden the heart of man and make the desert blossom as the rose.

The direct action of the solar rays, combined with the heat and moisture dispensed by the curious mechanism put in play by the solar heat, is the most considerable element in climate, the peculiarities of which are too minute for philosophy to follow. The influences of climate are neither few nor small. So sensitive is man to the smallest modification of climate, that he is always willing to construe some occasional and extraor-

dinary excess into a permanent change. These excesses are no indication whatever of climate. Occasionally we read in books that the Black Sea or the Baltic, the Euxine or the Propontis, were frozen over; that the harbor of Genoa, Leghorn, Marseilles, or Venice was blocked up with ice; that wine was split with a hatchet in Flanders; that the Thames, the Rhine, the Seine, the Hellespont, and many other rivers of Europe have been frozen so that carriages crossed them; that fires were kindled, fairs held, and oxen roasted upon them; that armies encamped on them, or crossed over them, as on solid ground. Such things would be extraordinary now; they were equally extraordinary then. On this subject Mr. Thompson makes the following remarks:—

“That human agency may be subservient to producing considerable local changes in the temperature of the seasons, by draining marshy countries, cutting down forests, and bringing the soil under cultivation, cannot be doubted; but it has been shown by Arago, in a series of collected observations, extending back to a century before the birth of Christ, that, upon the whole, there is no material alteration in the temperature of the seasons. Schouw has demonstrated the same; and by a happy accident, which has restored Raineri’s early Florentine registers, Signor Libri has shown that the climate of Northern Italy is now the same as it was in the days of Galileo.”

Who has not observed that the hottest and the coldest days ever experienced at the same place often fall into a single year? Dureau de la Malle, in a memoir on the climate of ancient and modern Italy, presented to the French Academy in 1848, uses the following strong language:—

“I terminate by affirming that the epochs, or at least the limits, of the different agricultural labors, and the several phases of vegetation, are, for the same localities and the same altitudes, identical in ancient and modern Italy; and, finally, that from the age of Augustus to the present era, the climate of Italy has not undergone any sensible modifications in its mean temperature, its annual or even monthly.”

The climate of a country is not made or unmade by a day or a year. Its virtues are distilled from a thousand separate influences. The transient excesses, caused by momentary accumulations of heat, moisture, or electricity, at particular

points, in spite of the perfect system of transportation and equalization of which we have spoken, have not power to produce so much as a ripple on the even surface of the general climate.

Man is not able wholly to resist the physical influence of climate; still he has a great capacity of endurance against excesses of the most opposite character. In Nubia, the thermometer sometimes reaches 130° Fahr.; and when exposed to the sand and the sun, it has mounted to 150° . Thompson relates, that Griffiths observed the thermometer in the desert near the Euphrates ascend during land winds to 130° in the shade, and 156° in the sun. Turn now to the opposite extreme. Gmelin, the elder, who explored Siberia, records the temperature on one occasion as being 20° below zero in Fahrenheit's scale. Captain Parry has recorded it at 55° , Capt. Franklin at 57° , Capt. John Ross at 60° , and Capt. Back at 70° ; all below zero. Mr. Thompson has enlivened his work with the following description by Captain Lyon, who had been transferred in a short period from Africa, the hottest region in the world, to the winter quarters of Captain Parry, in the coldest.

"At our first quarters, my clothing, with the exception of a thicker jacket, was the same as I had worn during summer. I never exceeded one pair of thin worsted stockings, neither did I find it requisite, unless the weather was windy, to wear either a great coat or comforter when walking out. There were two or three others equally insensible to the cold as myself; but the change of climate had an effect on me, which, I believe, was not experienced by the rest, and which was, that the hair from my head regularly *moulted*, if I may be excused the expression, and was renewed two or three times; even in the summer following, and in this second winter, the process still continued, although in a slighter degree. My health all this time was better than I had ever enjoyed for so long a period. But we all felt now the necessity of putting on additional clothing, both while below, and when walking out; coldness in the feet was, I believe, the most general complaint. . . . Our stove-funnels collected a quantity of ice within them, notwithstanding fires kept up night and day, so that it was frequently requisite to take them down, in order to break and melt out the ice, as it collected in the same form as the pulp of a cocoanut lies within the shell."

Degrees of temperature vastly exceeding any which occur

in the routine of atmospheric changes have been endured for a few minutes. Sir Francis Chantrey exposed himself to a temperature of 320° in his drying furnace.

Let us next contemplate the relations of the atmosphere to electricity and magnetism. These relations, though subordinate, certainly, to those of gravity, elasticity, and heat, must not be overlooked, as they have sometimes been by those who undertake to construct meteorological theories. We may not be able to point, with confidence, to any grand central orb pouring down electricity upon the earth as the sun pours down heat. Nevertheless we are at no loss for the origin of those electrical disturbances which are renewed every day, and sometimes acquire a fearful magnitude. Not an atom stirs, no chemical, physical, or mechanical change occurs to a body, no animal or vegetable function is discharged, without the evolution of its equivalent of the magical fluid. No drop of vapor leaves the earth's waters, no portion of a cloud recondenses into rain, no winds blow, rubbing against each other or against the rough planet, without contributing, each smallest particle its mite, to swell the electrical wave, What wonder, therefore, when the bridle is taken from the atmosphere, when the rains descend, and the floods come, and the winds blow, that the electrical force also should overleap its equilibrium to afflict and destroy? The experiments of Franklin and his cotemporaries with kites and vertical rods; the recent experiments of Weekes, Crosse, and others, with long wires suspended horizontally like the telegraph wires, have made men of science at home even with the lightning. Mr. Thompson states, that "in 1811, at Philipsthal, in Eastern Prussia, an enormous block was shivered in a thunder storm, by means of a tall iron rod duly provided for the purpose." Here the lightning was deliberately used to blast rocks.

Arago, in his eulogy upon Volta, in 1831, took occasion to assail the claim of Franklin to the discovery of the electrical character of lightning; a claim which the whole scientific world had been proud to acknowledge for three quarters of a century. Arago contends, that if the merit of the discovery consists in the first intimation of the identity of lightning and electricity, then it belongs to Nollet; if the merit consists in the experimental proof of this identity, then it belongs to another of his countrymen, D'Alibard; so that

France has it at any rate. In our opinion, the merit of a conjecture belongs to him who first started it, and the merit of the experimental proof belongs to him who originated that. Which has the greatest merit, the conjecture or the experimental demonstration, must be judged by their fruits. We further assert, that the merit of the first conjecture does not belong to Nollet, and that the merit of the first experimental proof does belong to Franklin. Nevertheless the passage from Nollet is very remarkable. We take it as Kaemptz has given it.

“If any one, after comparing the phenomena, undertook to prove that thunder is in the hands of nature what electricity is in our own; that those wonders, which we now dispose of as we wish, are trifling imitators of those great effects which terrify us; that the whole depends upon the same mechanism; if he should show that a cloud prepared by the action of the winds, by heat, and the mixture of exhalations, is, in respect to a terrestrial object, what the electrized body is when in presence and at a certain distance from the one which is not so; I acknowledge that this idea, if it were well maintained, would please me much, &c.”

This passage was published in 1748. But Mr. Gray, in 1735, had expressed the hope “that there may be found out a way to collect a greater quantity of electric fire, and consequently to increase the force of that power, which, by several of these experiments,

‘*Si parva licet componere magnis,*’

seems to be of the same nature with thunder and lightning.” Hawksbee, Wall, and Winkler all shared in this conjecture, and some of them anticipated Nollet in it by nearly half a century. So much for the conjecture. Then as to the experiment, we wholly disagree with Arago as to the value to be put upon it. He thinks the identity so obvious, that an experiment was almost useless to prove it. The identity was no doubt obvious to him; but it is the experiment which has made it so. Now, to whom does the merit of the experiment belong? Franklin, in a letter to a friend, which was published to all Europe, suggests two methods of making the experiment; by a rod or by a kite. D’Alibard, following, as he is careful to say, the method which Franklin had pointed out, obtained a spark from a rod on the 10th of May, 1752. Franklin drew down the lightning on the kite-string on the 15th of June.

We should not have felt it necessary to recur to this opinion of Arago in regard to one of the most brilliant discoveries of the American philosopher, had not Martins, the translator of Kaemptz's meteorology from the German into the French, showed a disposition to renew the claim for France, though upon a different ground; and did not the note in which his opinions are expressed appear also in the English translation which has been made from the French. Kaemptz, after doing justice to Nollet and others, who had conjectured the identity of electricity and lightning, uses these words: — "To study the electricity of the clouds, Franklin was the first to employ the electric kite." On the paragraph of which this is a part, Martins has this note: "Franklin, in his excellent work on the influence of points, had indicated the means of investigation which he proposed using to study the electricity of the clouds; but it was in 1752, that D'Alibard was the first to mount at Marly-la-Ville a fixed apparatus with which he drew forth sparks from a storm cloud, and it was Romas who first sent up the electric kite, in the same year." This is all true. But why does not Martins tell us how Romas succeeded? He sent up his kite on the 14th of May. He selected the day because it was showery. It had rained, he tells us, ten times. *Still he could not get a spark.* On the 17th of June, he tried again and succeeded. But Franklin's experiment had already been made triumphantly. We will only add the hearty words with which Thompson closes his review of the subject, though he makes no reference to the recent demands set up by the French philosophers which we have been discussing.

"The letters of the modest and perspicuous American were rejected for publication by the Royal Society of London. In England and France, opposition arose — violent, puerile, and sickening. Truth triumphed over the Abbé Nollet and our countrymen. Priestley at home, and Beccaria in Italy, entered the lists, and defended Franklin. The Royal Society elected him a Fellow, and, as if to atone for past faults, presented to him a medal! The Fellowship conferred upon him less honor than he did upon it; it may be forgotten, and the medal may moulder in darkness; but the name of Franklin will endure, and beam with greater radiance in ages yet unborn, in proportion as this subject is studied and new truths are unveiled. The time is on the wing, when not only in India, but in Polynesia and

Central Africa, the experiment of the electric kite will be familiarly known to every schoolboy, and the fame of Franklin wide as the world."

In reviewing the electrical relations of the atmosphere, the aurora must not be forgotten. Whoever has witnessed the beautiful experiment of sending friction electricity through a tall exhausted receiver will confess the resemblance of this electrical light, both in its colors and its motions, to the aurora, or skipping goats, as it has been figuratively called. The Indian believed that the aurora is the descending spirit of his fathers; the philosopher has taught that it is the magnetism of the earth spouting out from the magnetic pole; or that it arises from vapors and exhalations which have ascended to such a height as to be outside of the shadow of the earth, and to be illuminated by the sun. Captain John Ross explained the auroral light by the reflection of sunlight from the brilliantly colored ice and snow of the polar seas. Though it may not be possible, in the present condition of science, to sketch all the parts of the delicate machinery by which this grand exhibition is produced, still the opinion at the present day is almost universal, that the phenomenon is electrical. It is not strange, that the vapor which goes up should carry with it latent electricity as well as heat; it is not strange that this latent electricity should be freed when the vapor forms cloud; that the greatest amount of electricity should be set free in high latitudes, where the condensation is the greatest; that the electricity abandoned to itself should seek the earth again, as lightning or as the aurora. But how shall we explain the symmetry of the auroral lines? If the laws of perspective are applied to them, the complex arrangement is reducible to beams parallel to one another and to the magnetic axis of the earth. What is the substance of these conducting lines, and why they take that position, no one is able to say. Biot remarks, "But of all terrestrial substances, only the metals, so far as we know, are in any considerable degree susceptible of magnetism. It is, then, probable that the columns of the meteor are, at least in a great measure, composed of metallic particles reduced to powder of extreme fineness." Mr. Faraday inclines to the opinion that all bodies, the solids as well as the liquids, are represented in the atmosphere by their vapors, which have gone up at ordinary temperatures.

To prepare the way for a satisfactory physical explanation of the aurora, it is essential to exclude all that is merely traditional, or about which there are contradictory reports. The light of the aurora is what especially signalizes it. This is comparatively faint. When the whole hemisphere is illuminated by it, the light does not exceed that of the full moon. Artificial electricity, when it traverses the thin air in the receiver of the air-pump, is very faint. But the atmosphere, in the region to which the aurora belongs, is highly attenuated, to a degree unapproached by the best artificial vacuum, if we adopt the larger estimate of the height of the aurora. It has been computed, that a single cubic inch of common air could, by expanding, fill a sphere as large as Saturn's orbit with an atmosphere equal in density to the earth's atmosphere 500 miles above the surface.

It has been asserted that the aurora addressed other senses besides the eye. Trevelyan learned in Farøe, that it was accompanied by a peculiar smell. In still more decided language does Gmelin, in his account of Siberia, speak of the sounds emitted by the aurora. "However beautiful this spectacle may be, I think it will be impossible to contemplate it for the first time without emotions of terror; so constantly is it accompanied, as I have been informed by several intelligent persons, with noises like those hissings and cracklings produced by very large fireworks." The testimony of the inhabitants of the Shetland Islands is equally full and complete. Edmonston relates, that in a voyage between London and the Shetland Islands, an aurora appeared, vivid and loud; "the noise with which it was accompanied was such that the sailors were afraid to remain on deck." Biot, to whom we are indebted for these cases, gives his own opinion in these words:—"It seems probable, after this mass of testimony, that the meteor sometimes descends so low as to allow us to hear the noise proceeding from it." On the other hand, scientific travellers, who have made the aurora an object of special study, do not allude to these sounds, and Captains Parry and Scoresby expressly say, that they never heard them. In one of Franklin's expeditions, an officer heard a hissing noise, such as might be made by a bullet, passing through the air, which he attributed to the aurora; but his companions explained it by the action of the

severe cold on the snow. "The auroras," says Humboldt, "have become more silent since observers have better understood how to observe them, and how to listen for them."

It is a common opinion that the aurora occurs more frequently now than it did one or two centuries ago. Halley waited to see an exhibition till he had almost ceased to hope. Celsius says it was more rare in Sweden previous to 1716 than it has been since. Between 1716 and 1732, it was observed 316 times. Mairan, who in 1754 published a great work of classical authority on the subject, enumerates 1441 appearances only, between the years 583 and 1751. It is his opinion that these exhibitions were not distributed indiscriminately during this long period, but were crowded into distinct epochs, of which he is able to separate 22 distinctly from each other. Before adopting such an opinion, great weight must be given to the increased number of observers and to the more favorable position which they enjoy. In high latitudes, the aurora is almost as common as the rising of the sun. The French scientific commission, which spent some time at Finmark in 1838 and '9, witnessed 150 displays in 218 days. Captain Lefroy has taken measures to have the aurora observed at all the regimental guard-rooms in Canada, Nova Scotia, and Newfoundland. In 1848-9, the number of exhibitions, compared with the number of nights when they would have been visible if they were produced, amounted to between 19 and 33 per cent. for different places; though generally the aurora was not looked for after midnight. On two occasions, the same aurora was seen at all the stations, which were distributed over an area of 1,150 miles in longitude and 140 in latitude. These and other observations made in British America have suggested to Captain Lefroy, that the aurora was not unmindful of the hour of the night, but was visible about 10 or 11 in the evening more frequently than at other hours. If these observations are continued for several years, and others like them made in the United States, the theory can be fairly tested whether the aurora, like the falling stars, obeys a period.

Before we have the elements of a correct theory of the aurora, the immense discrepancies in regard to its observed distance must be reconciled. Some observers assert that the height of the aurora is 1,000 miles; others think as many

feet will be nearer to the truth. Parry thought on one occasion the aurora was between the observer and some rising ground only 3000 feet distant. The elder Ross saw it, as he supposed, between two ships, or between his ship and an iceberg. Some explain away these cases by the persistency of the impression on the retina. The extraordinary refractions, so common in high latitudes, might displace the aurora, as they disfigure and displace other visible objects. On the other hand, the parallactic determinations of the height of the aurora, which have placed it between 50 and 825 miles from the earth on different occasions, are open to the objection that the two observers, whose results become the elements of the calculation, may not be looking at the same object; that each observer may have his own aurora, as each has his own rainbow, and his own thunder and lightning. The point at issue is fundamental. While one class of distances keeps the aurora in our immediate neighborhood, in the region of clouds and other ordinary meteorological phenomena, the other lifts it into spaces not of the earth, but rather cosmical. Though elevated to unusual regions of the atmosphere, from which otherwise no report has ever come to science, we may still claim the aurora for the earth, as it partakes of its diurnal motion, and arranges its flashing lines so rigidly according to the direction of the earth's magnetic axes. Sir John Ross observed in 1818, while his ship was moving south from 74° latitude, that the auroras were seen to the south, till he reached the parallel of 66° ; after which, they swung round to the north. Almost every city and town, we presume, can sympathize sincerely with the vigilant firemen of London, who, according to Thompson, have turned out on several occasions to extinguish the aurora.

We conclude this division of our subject, on the electrical relations of the air, with the following sentence from Kaempts, in whose opinion we fully concur. "However, it appears to me demonstrated, that electricity is not the cause of the modifications of the atmosphere; and its most formidable manifestations occur, because the electricity liberated by the precipitation of the vapor of water cannot be neutralized except by a spark."

Finally, let us take a glance at the position which the light occupies in meteorology. According to the latest

researches of Melloni, the same individual rays from the sun which warm the earth enlighten it likewise. The well known want of proportionality between the calorific and luminous intensities of the same solar rays Melloni explains by an organic peculiarity in the eye itself; which is so tempered as to respond strongly to certain undulations, and feebly or not at all to others, with which its own harmonics are not in tune. The most intense undulations, mechanically considered, are not necessarily those which awaken the sensation of the brightest light. The intensity of the sensation depends in part on the pitch of the undulation, or on what we commonly call its color, and not exclusively on its intrinsic force. As the solar heat, distributed and economized by atmospheric agencies, ministers to the comfort of man, tempering the extremes of geographical position, and equalizing to a considerable degree the blessings of a provident nature, so the light of the sun kindles the face of creation into a smile and brings gladness to man's heart. But it is the atmosphere which converts the raw material from the sun into countless forms of unspeakable beauty; scattering the rich colors over the sky, breaking it into beautiful fragments to paint the rainbow, and ornamenting the dull face of nature with its mirage, its halos, its extraordinary refraction, and its stellar scintillation. If heat is the useful handmaid of the earth, the light is the ornament and grace of our planet.

After the solar radiations, clothed with their triple charm of light, heat, and chemical action, have reached the earth, they convert the part of it which they impinge upon into a centre of secondary radiations; these secondary radiations, however, are so modified by the gross material from which they spring, so reduced in pitch, it may be, as no longer to possess the power of acting on the eye. Hence the means divinely appointed for distributing the light to the scattered pilgrims on the earth are different from those which transport the heat. The exquisite experiments of Melloni have proved, that the heat has not been wholly sifted from the moonlight. Nevertheless the moon's agency in warming the earth is wholly insignificant. But in illuminating the earth, the moon is second only to the sun. By beautiful and simple astronomical arrangements, the full moons of winter run high, and remain above the horizon more than half the day. This

compensation for the absence of sunlight is perfect in all its details. At the poles, during the sun's six months' absence, the moon keeps an incessant vigil, only sinking below the horizon at her change, when her dark side is turned to the earth and her presence is useless. Laplace was led by his analysis to the conclusion that, if the moon were placed opposite to the sun and about four times as far from the earth as she now is, and then started in her new orbit with a certain velocity, she would always remain in opposition. As she would be too far off then to receive the earth's shadow, we should have a full moon every night. If the earth were a gainer, the moon certainly would be a loser. If the moon were always full to the earth, the earth would never be full to the moon, but ever new. If the earth were ready, would the moon consent to this proposed amendment to the solar system? As the light of the moon would then be sixteen times less to us than the present light of a full moon, perhaps even we should not consent.

Let us not undervalue the meteorological provision for equalizing the light. The atmosphere, by refracting and reflecting the sun's rays, anticipates for us his presence in the morning, and makes his rays still linger over our heads in the evening. The same astronomical cause which keeps the sun below the horizon six months at the pole, prolongs the twilight, which at the equator is only an hour, to four and a half months. But the refractive and reflective powers of the air carry to still greater extremes the duration of twilight, and always in favor of the poles.

"In the interior of Africa," says Kaemptz, "where the air is sometimes so pure and so transparent that Bruce, when in Sennaar, saw the planet Venus in broad daylight, night immediately succeeds sunset. On the other side of the Alps, in Dalmatia for instance, night occurs half an hour after sunset. Between the tropics, twilight is still shorter; it lasts a quarter of an hour at Chili, according to Acosta; and a few minutes at Cumana, according to M. de Humboldt. The same phenomenon occurs on the coast of Africa. These results differ very manifestly from those obtained by calculations, according to which twilight ought to last at least an hour. We are, therefore, obliged to admit that, between the tropics, the sun is not so far below the horizon at the end of twilight as it is in the very high latitudes."

If the refractive power of the tropical air falls below the

average, that of the polar air exceeds it. On the 3d of February, 1820, when Captain Parry was in latitude $74^{\circ} 47'$, the sun made his appearance after an absence of ninety-two days, three days sooner than calculation predicted. On the 24th of January, 1597, Barentz saw his disc at Nova Zembla fifteen days before he was expected to return. If meteorology can produce such permanent and material disturbances in the precision of astronomical calculations made for different latitudes, we shall not be surprised at occasional excesses of atmospherical refraction anywhere. In 1750, the sun was still above the horizon at Paris, when the moon rose in a total eclipse. The same phenomenon was witnessed in Great Britain in 1837. In these cases, the amount of refraction was not unusual; but its reality was brought home to the senses in an extraordinary manner. We have read with a little surprise the following remarks of Mr. Thompson, which seem to carry us back to the good old days of meteorology.

“This recalls to mind the miraculous lengthening of the day when Joshua was engaged in combat with the Amorites. Then the sun did not set on Gibeon, and the moon tarried in Ajalon. Though we doubt not the power of him who said and it was done, to hold the earth ‘in the hollow of his hand,’ while it ceased to perform its diurnal revolution — to stay the moon in her orbit, and prevent her rotating on her axes — to interpose his almighty arm between the other members of the system and physical disturbances — these, and more if required, we freely grant, still we humbly think, that this miracle was wrought by the secondary influence of an unusual refraction. Another miracle, which we would explain in a similar way, was the returning of the shadow on the dial of Ahaz.”

Indispensable as is the light to the physical well-being of man, to the perfection of vegetation, to valuable processes of art, and as an instrument of research opening to him an infinitude of worlds of which otherwise he would be ignorant, the alternation of light with darkness exercises an important influence on civilization. Mr. Thompson has enriched his book with the following description by Captain Beechey of the effect of perpetual sunshine.

“The novelty it must be admitted, was very agreeable; and the advantage of constant delight in an unexplored and naturally

boisterous sea was too great to allow us even to wish for a return of the alternations of day and night. But the reluctance we felt to quit the deck when the sun was shining bright upon our sails, and to retire to our cabins to sleep, often deprived us of many hours of necessary rest; and when we returned to the deck to keep the night watch, if it may be so called, and still found the sun gilding the sky, it seemed as if the day would never finish. What, therefore, at first promised to be so gratifying, soon threatened to become extremely irksome; and would, indeed, have been a serious inconvenience, had we not followed the example of the feathery tribe, which we daily observed winging their way to roost with a clockwork regularity, and retired to our cabin at the proper hour, where, shutting out the rays of the sun, we obtained that repose which the exercise of our duties required."

Throughout the whole of this review of the various relations of the atmosphere, who can fail to acknowledge the Divine Artificer who has organized it for the wonderful services it must perform? Every living thing draws nourishment from it, though it is made up of elements which, chemically combined, compose either an irrespirable medium, an intoxicating draught, or a virulent poison. It conveys sound, and obstructs less than any other substance the light and heat. The thinnest slice of a crystal can alone compete with the air in transparency, though the thickness of the latter exceeds 40 miles. One half of the solar rays of heat reach the solid earth when they pass perpendicularly through the atmosphere, and one quarter of the light. So transparent is the air in Persia that the stars do not twinkle; and among the Andes, the *poncho* or mantle worn on horseback can be seen at a horizontal distance of 16 miles. Even the inertia of the atmosphere has been turned to good account. When the air is in motion, it wafts our ships and turns our machinery; when it is at rest, it is an ever present defence around each city and home, protecting it by night and day from the distant assaults of the unprincipled and ambitious.*

The glance we have cast at the applications of physical science to meteorology will give some idea of the range of subjects pertaining to the latter, and which both our authors have thoroughly handled; though neither of them in the exact

* A 24-pound shot which might, *in vacuo*, reach the horizontal distance of 125,000 feet, is reduced by the resistance of the air to a range of 7,300 feet.

order in which it has seemed proper to us to introduce them. A great variety of topics, belonging to the natural history of the science, are not omitted by either ; but we have no time to dwell upon them. The falling stars, once styled meteors *par excellence*, are now admitted into works on meteorology by virtue of one out of four hypotheses to explain their origin, and that by no means the most probable one. Mr. Thompson discusses them, and Mr. Kaempts gives them a corner in his short chapter on problematic phenomena. We pass over the subject, as it has already been ably treated in the pages of this Review. Mr. Thompson affords a page or two to the zodiacal light ; but its title to admission is of no value, and Kaempts silently rejects it. Thompson gives the authority of Laplace for discarding the theory that the zodiacal light belongs to the sun's atmosphere.

"The sun's atmosphere," says Laplace, "can extend no farther than to the orbit of a planet whose periodical revolution is performed in the same time as the sun's rotatory motion about its axis ; or in $25\frac{1}{2}$ days. Therefore, it does not extend so far as the orbits of Mercury and Venus ; and we know that the zodiacal light extends much beyond them. Again, the ratio of the polar to the equatorial diameter of the sun cannot be less than $\frac{2}{3}$ (for when the centrifugal force at the equator just equals gravity, or the atmosphere is most compressed at the poles, this is the ratio) ; now, the zodiacal light appears under the form of a very flat lens, the apex of which is in the plane of the solar equator. Therefore, this fluid is not the solar atmosphere."

Mr. Thompson makes no reference to the preceding passage, which we have extracted from the "*Mécanique Céleste*" of Laplace, as containing the most exact exposition of his views in relation to the zodiacal light. Humboldt in his *Cosmos* refers to it. But unfortunately he has paraphrased the passage, instead of using the words of Laplace ; and has fallen, therefore, into an inaccuracy of statement very unusual for him. These are the words of Humboldt : —

"This phenomenon, whose primordial antiquity can scarcely be doubted, and which was first noticed in Europe by Childrey and Dominicus Cassini, is not the luminous solar atmosphere itself, since this cannot, in accordance with mechanical laws, be more compressed than in the relation of 2 to 3, and consequently cannot be diffused beyond $\frac{2}{3}$ of Mercury's heliocentric distance. These same laws teach us, that the altitude of the extreme boundaries

of the atmosphere of a cosmical body above its equator, that is to say, the point at which gravity and centrifugal force are in equilibrium, must be the same as the altitude at which a satellite would rotate round the central body simultaneously with the diurnal revolution of the latter."

The words which we have italicized are not a consequence of the proposition to which they are appended, but of the proposition which follows.

Oersted, the distinguished philosopher of Copenhagen, observes, that little has been done in discovering laws of meteorology, because men have sought to find out the first change in the atmosphere, and have had an overstrained regard for some comprehensive principle, instead of carefully collecting facts and tracing the proximate causes. Without meaning to take the least exception to the truth of this remark, we still believe it to be incumbent on the scientific meteorologist to have a high aim, and never to lose sight of it. Else, how shall he know what to observe among the countless phenomena which crowd upon his vision, and how to dispose of what he has observed? The indiscriminate collection of meteorological details is not science, any more than a heedless picking up of stones is geology, or the bare counting of the stars is astronomy. In examining the two works under review according to this standard, the scientific reader will have no difficulty in distinguishing the peculiar cast of each. Mr. Thompson calls his work an introduction to meteorology; while Mr. Kaempts aspires to a complete course of meteorology. Each work is true, and perhaps equally so, to its title. Thompson's work is replete with information, enlivened by anecdote, and embellished by poetical allusions. It is written in an elegant and generally accurate style, always beautiful, and sometimes eloquent. And what is of no small moment in a book of facts, it contains very few typographical errors. The work of Kaempts is more severe in its object, and more sober in its style. Probably the language of no author does perfect justice to his thought. In the present instance, we do not read his words, but the translation of a translation, so that the ordinary insufficiency of language is raised to the third power. Beneath all this, however, we see the strength, clearness, and caution of the author's mind, and the approximation he makes to a dynamical view of meteorology. Kaempts does not study the periodical changes in the barometer, thermometer, and

hygrometer, by themselves, but in combination with the prevalent winds which accompany them. The general climate of a place, as well as the particular weather, depend on the temperature and moisture of these winds; and this temperature and moisture depend on the direction of the winds, in other words, on the latitude and geographical peculiarities of the countries from which they come, compared with the latitude and geographical peculiarities of the countries to which they go. Yes, the winds, the fickle and unsteady winds, are the landmarks in meteorology; and as soon as a correct dynamical theory of these winds is matured, an ample and solid foundation will be laid for the whole science.

In 1827, Dove attempted to complete the theory of the winds, by applying to the irregular winds which blow in the middle latitudes the same solution which had been given for the regular trade-winds of the tropics. As the history of this solution is often given with a great lack of precision, (being attributed sometimes to Halley, sometimes to Hadley, and by Kaempts indiscriminately to both,) it may be worth while briefly to recapitulate it. Two centuries ago, Descartes ascribed the trade-winds to the inertia of the atmosphere, which did not acquire the full speed of the equator, but always had a relative motion westward with respect to the solid land. Galileo also recognized in the trade-winds the evidence of the lagging of the atmosphere. Bacon, rejecting, as he did, the Copernican system, and believing the earth fixed, explained the trade-winds by supposing the air, which was of the heaven heavenly, to partake of the diurnal motion of the heaven westward. In 1686, Dr. Halley referred the trade-winds to the confluence of air into the space which had just been heated by the sun. Halley took no account, in his theory, of inertia, but rested exclusively on the agency of heat; Descartes, on the contrary, neglected the heat, and placed his sole reliance on the inertia which Halley repudiated. In 1735, Hadley gave the true solution, now universally received; combining the effect of heat, which raises a vertical current, with the inertia of the air as it changes its parallel of latitude. Dalton, a great philosopher, but not a scholar, reproduced Hadley's theory in 1793, without being aware that he had been anticipated; a mistake into which he fell on other occasions, and for a similar reason, namely, want of familiarity with the history of science. Dalton said that De Luc was, so far as he knew,

the only person who had given any weight to inertia. We should not fail to remark, that the accepted theory of the trade-winds, original with Hadley and Dalton, is not a happy mixture of conflicting views ; for the heat and the inertia which figure in it play parts wholly different from the unphilosophical ones assigned to them by Halley and Descartes. The inertia, as it was applied by Descartes and Galileo to the explanation of the trade-winds, is not a *vera causa*. For, however much the air may have lagged behind when the earth first began to turn, it must ere this have acquired by friction the common diurnal motion. This objection does not hold against the use which Hadley and Dalton made of inertia. So long as air continues to come from the poles, it comes with an insufficient velocity of rotation, so that the trade-wind is perpetual. Moreover, the loitering of the air would be greater as it was higher above the earth, whereas in fact the upper strata move in the opposite direction to the lower, and, therefore, faster than the solid mass. Again, the influence of heat as applied by Halley to the explanation of the trade-winds is no better. If the air follows the sun, it must circumnavigate the earth in a day. Such a wind never has been witnessed ; much less is it the gentle trade-wind, with which the ship performs her voyage from continent to continent without once taking down her royals. The only approximation to Hadley's theory was made by Hooke. He availed himself of the sun's rays to make an ascending current at the equator, and thence a polar current in the lower stratum, and an equatorial current in the upper stratum ; but he clung to the favorite idea that the air hung back from the diurnal motion, or outran it, to explain the easterly and westerly elements of direction in these two currents. Humboldt, who in other respects has given the history of the theories upon the trade-winds very elaborately, has lent his aid to perpetuate the confusion of the very different views of Halley and Hadley upon this subject. Humboldt says in his *Cosmos*, "Hooke's more correct view was taken up by Halley late in the eighteenth century, and was then more fully and satisfactorily explained with reference to the action of the velocity of rotation peculiar to each parallel of latitude. Halley, prompted by his long sojourn in the torrid zone, had even earlier (1686) published an admirable empirical work on the geographical extension of trade-winds and monsoons." As

Halley died in 1742, as his theory rejected "the velocity of rotation peculiar to each parallel," and as Humboldt adds in a note that the theory of Galileo must not be confounded with that of Hooke and Hadley, — we think Humboldt must have intended to write Hadley instead of Halley, in the first sentence above quoted. The recurrence of the name in the next sentence, where no one but Halley can be meant, does, we confess, clash somewhat with this attempted solution of the mistake.

We cannot agree with Dove when he says, that no one has gone beyond Halley in explaining the winds. The error into which Dove has fallen does not interfere at all with the merit of his own labors. It occurs to his clear mind, that the upper and southwest current, which is moving from the equator to the north pole, must occasionally sink and displace the lower and northeast current, which is blowing from the north pole to the equator; so that, instead of regular winds, like the trades in the tropics, where one of these currents has the supremacy, there are irregular winds in the higher latitudes, depending on the conflict of the two antagonistic currents. The prevalence of either of these winds at a particular time and place, with its characteristics of temperature and moisture, determines the essential features of the weather. By this theory, Dove is able to explain a phenomenon well known to Bacon, which is vulgarly expressed by saying that the wind does not back in, but has a progressive change of direction, from the east through the south to the west. "*Si ventus se mutet conformiter ad motum solis, non revertitur plerumque, aut si hoc facit, fit ad breve tempus.*" This applies to the northern hemisphere only; in the southern hemisphere, the rotation of the winds is from the east through the north to the west. The physiognomy of the earth, the outline of the contact of the land with air and water, derange this general dynamical action, as the most regular part of it, the trade-winds, is deranged in the eastern hemisphere, and converted into monsoons.

If the sun moved always in the earth's equator, the theory of the winds might stop here. But the parallel to which the sun is vertical shifts in the course of the year, from 23° south latitude to 23° north latitude. As the sun advances upon us from the equator, the southeasterly trade-wind of the southern hemisphere follows it, encroaching on the zone of which the northeast trade-wind is in possession. As the southeasterly

current passes into the northern hemisphere, it becomes south-westerly with regard to the solid earth, which it surpasses in velocity of rotation. In the neighborhood of the northern tropic, we have a struggle every summer between this south-westerly trade from the other hemisphere, and the polar current from the north. The effect of the collision is twofold : — a rotation of the air from north through the west to south, and a diminution in the motion of the great body of it towards the west. As soon as this column of southern air has ploughed through the northern trade, and reached the southwesterly winds of higher latitudes, where the westerly motions conspire, it changes its progressive direction suddenly towards the east, and no longer feels the power which makes it whirl. Hence the origin of the tropical hurricanes ; hence the derivation of their whirlwind character ; a character which Reid, Redfield, and others have deduced from their practical study of hurricanes. Hence the progressive motion of the hurricanes, first towards the northwest, and then with a sudden turn towards the northeast. Hence their diminished violence after they have passed the tropics. Hence the season of the year at which hurricanes most abound. When the sun has gone back from the northern to the southern hemisphere, the polar current from the north follows it, and makes reprisals in the other hemisphere for the interruption it has suffered in its own. Hence the hurricanes of the southern hemisphere, the season when they occur, and the direction in which they turn. Truly may it be said, that Dove, while sowing to the wind has reaped the whirlwind.

To some, a meteorological theory will have no value if it cannot explain the exceptional and wonderful phenomena of the atmosphere. Such persons will be disappointed with the work of Kaempts. The true meteorologist, says Kaempts, gives no more value to these extraordinary things than the zoölogist to monstrosities. To all those who tell strange stories in regard to showers of frogs, fish, and other small animals, Kaempts has no other answer to give but that of one of the most distinguished naturalists of the age, made to one who told him he had seen one of these phenomena : — “ It is fortunate,” he said, “ that you have seen it, for now I believe it ; had I seen it myself, I should not have believed it.”

There is another class of amateur meteorologists, who are

ever seeking for a sign. "Never," says Arago, "whatever may be the progress of the sciences, will the *savant* who is conscientious, and careful of his reputation, speculate on a prediction of the weather." Mr. Thompson quotes this remark, and seems to subscribe to it. Still, he has a care for those who have less reputation, and are not afraid of losing it. He tells them that, in the Polish mines of Viclizka, near Cracow, a large block of salt, called Lot's wife, indicates to the miners the hygrometric condition of the atmosphere above. An aurora was seen in New England, Dec. 11th, 1719, (said to have been the earliest witnessed in this country,) which filled the Colonies with consternation. A writer in the Boston News-Letter closes his description of it with these words: — "As to prognostications from it, I utterly abhor and detest them all, and look upon these to be but the effect of ignorance and fancy; for I have not so learned philosophy or divinity as to be dismayed at the signs of heaven; this would be to act the part of a heathen, not of a Christian philosopher."

We have spoken of the general character and contents of the two works under review. It only remains to say a word in regard to their scientific and typographical accuracy. In regard to the work of Mr. Thompson, we have little to add on this point to what has already been said. His book, though not wholly free from errors, chargeable sometimes to the press and sometimes to the author, displays marks of care in all its details. No less praise must be bestowed on the original work of Kaemptsz. Perhaps we might take exceptions to general statements of facts, which are true only in a limited sense, and when applied to a particular continent. For example, Kaemptsz says: "Daily experience has long taught us that the air is not equally moist with every wind. When the farmer wishes to dry his corn or his hay, or the housewife spreads out her wet linen, their wishes are soon satisfied if the wind blows continuously, but a much longer time is required with a west wind. Certain operations in dyeing do not succeed unless during east winds." The work of Kaemptsz contains several elaborate Tables, which will prove useful to the practical meteorologist. A French translation of this book (which was published in 1840) was made in 1843 by Martins, an eminent philosopher who has had large experience in meteorological observations. This trans-

lation is very free, and at the same time so condensed as to imperfectly express the ideas of the original. In some cases it has been made without sufficient care. In one or two instances, more than half a page has been omitted by accident or design; we do not include the changes which Martins notices in his preface. This French translation is the basis of that which we have been reviewing. The English translator, Mr. C. V. Walker, is already known as an author; he edits a scientific magazine, and has himself been engaged in investigations connected with electricity. The translation of this important work of Kaempts, which according to the united confession of Martins and Walker is the only complete treatise on meteorology in any language, will not add to his reputation. He adheres to the French idioms and words so closely that the language becomes absurd. In only one instance, so far as we know, has he corrected even an error of the press, (p. 451); and frequently he commits mistakes inexcusable in a translator or a man of science.

On page 105, we read, "But air at 15° being able to contain only $13^{\text{m}}.44$ of vapor, the mixture will have 52 per cent. of vapor of water." This is a literal translation of the French; but the "only," which has no equivalent in the German text, darkens the sense of the passage. On page 121, we read, "When the ascending current relaxes toward evening, the clouds descend; as [*et*] on arriving into strata of air which are less heated, (*plus chaudes*,) they again pass into the state of invisible vapor." On page 141, a defect in the French text has been copied, without reflection, into the English translation. "During whole days, the sun is invisible in England, whilst a clear sky is extended over continental Europe; in summer it is precisely the contrary." Here is the statement of Kaempts: — "*Tage und Stunden vergehen im Winter in England, während welchen die Sonne nicht durch die Wolkendecke dringt, dann hat das Festland häufig das schönste heitere Wetter, während dieses im Sommer,*" &c.

On page 156 occurs another passage, in which the English translator blindly follows his blind guide into a greater blunder. "When the sun is very far from the zenith, that is to say, when it is in the northern hemisphere, during the months of December and January, the temperature is relatively very low." The German runs thus: — "*Ist nämlich die Sonne*

am weitesten vom Scheitel entfernt, (also, in der nördlichen Halbkugel im December und Januar) so ist die Wärme am kleinsten;" which we thus render: — "Is the sun removed to its greatest zenith distance, as is the case in the northern hemisphere in December and January," &c.

An inaccuracy which both our translators share, may be found on page 176. "Annual vegetables, and especially those of the corn tribe act in a different manner. The hardness and vigor of the winter little concerns them. The only thing essential to them is the period during which they are developed; thus the curves that indicate their northern limits are parallel to the isotherals. *In Norway, barley is cultivated in certain places situated under the 70th degree.* Towards the east, its limit falls southerly, and in Siberia none of the corn tribe are found north of 60°." The German, which corresponds to the part in italics, is: — "*Im innern von Norwegen und Lappland kann noch in einer Breite von 70° Getreide gebaut werden, was an der Meeresküste erst mehrere Grade weiter südlich möglich ist.*" On page 190 is this statement: — "Besides their elevated temperature, these S. W. winds are also distinguished by their moisture, which is such that, in winter, they are almost entirely saturated with the vapor of water; hence the atmosphere of Europe and America is almost constantly foggy during that season." In the German and French it is, "western Europe and America."

The next case we shall mention is particularly discreditable to Mr. Walker, though the French translation is not perfect. "This is due to the little variation in the height of the sun in the different seasons, and to the difference of the constant sea and aerial currents that prevail in these regions."—p. 194. The French reads thus: *Cela tient à la faible variation de la hauteur du soleil dans les différentes saisons, et à l'influence des courans marins et aériens constans* (sondern in dem früher erwähnte Einflüsse der Passate und Meeresströmungen) *qui regnent dans ces regions.*"

In the next sentence, the English translator has been faithful to the French, but the latter gives any thing rather than the remark of Kaempts. "*Car ainsi que nous l'avons vu, la coté est d'Amerique est rechauffé par un courant equatorial, et la coté ouest rafraichie par un courant venant du nord.*" In the German it reads: "*Während nämlich neben Americas*

Ostküste das warme Wasser des Aequators fortläuft, und die nördlicher liegenden Punkte etwas erwärmt, finden wir neben Africas Westküste einen von Norden kommenden Meerestrom, welcher die südlicher liegenden Punkte erkaltet."

The French translation of the sentence which follows is equally defective, and the defect mars the English also. On page 205, Mr. Walker translates thus: — "Finally, between six and ten metres, the instrument indicates throughout the day (*pendant toute l'année*) a temperature which is very nearly that of the annual mean."

Again, on page 207: — "If it is collected in a subterranean reservoir, sufficiently deep, that the diurnal variations have no longer any power to act on it, it will acquire a certain degree of temperature. In passing out by any channel, its temperature will be modified by the sides of this conduit; it will, therefore, be reduced in winter and elevated in summer, especially if we think of the great capacity of water for heat." We will say nothing about the inelegance of the first sentence, but give the French of the last. "*En s'écoulant au dehors par un canal, sa température sera modifiée par les parois de ce conduit: elle sera donc abaissée en hiver, élevée en été, surtout si le canal est long et superficiel. Mais dans une source abondante, cette influence se réduit a peu de chose, surtout si l'on songe à la grande capacité de l'eau pour la chaleur."*

Another blunder meets our eye on page 210. "The law according to which temperature decreases, as to the limits of the atmosphere (*jusqu'aux limites de l'atmosphère*, even to the limits of the atmosphere) is yet unknown." "*Selbst wenn ein Kubikfuss dieser dünnen Luft eben so viel Wärme verschluckt hat,*" is rendered by Mr. Walker, on page 218, in imitation of the French, "even where a cubic metre of this rarefied air has not absorbed more heat than a cubic metre of denser air." "*Ein andere Unterschied zwischen Pflanzen in Hohe and Tiefe zeigt sich in der Lebensdauer der Gewächse,*" is translated literally from the French, "Another difference resides in the duration of the plants."—p. 224.

Again, we read in the German: — "*Wird nun der Luftdruck kleiner, so wird zwar der Gewichtsverlust auf beiden Seiten der Wage geringer, aber diese Verminderung ist für die grosse Kugel grösser und so wird sie schwerer, weshalb sie sinkt.*" Both translators reverse the statement thus: — "If,

then, the pressure diminishes, the weight (it should be loss of weight) of the two bodies, *in equilibrio*, diminishes also ; but that of the sphere diminishes less (it should be *more*) than that of the body ; it will, therefore, be heavier, and will descend.” —p. 237. An inaccuracy of the French text in the numbers which express the temperature correction of the barometer is inadvertently copied by the English translator on page 239.

“*Meine eigenen Messungen in Halle geben für die Wendestunden folgende Momente in wahrer Sonnenzeit in Stunden und Decimaltheilen derselben,*” is translated vaguely enough on page 250, in too close imitation of the French, “my series at Halle gives for the tropical instants the following moments in true time and in the decimal parts of an hour.” “*Bis endlich deshalb ein Maximum eintritt, weil die schnelle Abnahme der trockenen Luft ein Uebergewicht erhält,*” is translated literally from the French, on page 272, “and it attains its maximum when the pressure of the air begins to diminish.”

A gross blunder is made by the English translator on page 303. “If this coincidence did (*does*) not occur, then would there be (*are there*) lamentations without end on the inaccuracy of barometers in general, or of accusations against him who should be particular in observing it. It would be more wise to lament that a prejudice on this point could become rooted in the generality of minds.” The correct translation is : “If this coincidence does not occur, then there are lamentations innumerable on the inaccuracy of the barometer in general, or accusations against that one in particular which men have been observing. It would be more wise to mourn over a prejudice which was rooted to such a degree (*à ce point*) in the public mind.”

We pass only to the next page before we stumble upon another error. “For a long time philosophers vainly endeavored to explain the relation by which the two phenomena were connected ; De Luc was the first to point it out in general terms, and although his hypothesis does not induce (*ne soutienne pas une discussion approfondie*) a searching investigation, it is generally adopted.” —p. 304. “*Ganz dasselbe gilt von den Westwinden welche im Sommer so sehr vorherrschen,*” is rendered literally from the French, “The same remark for the west winds which prevail throughout the sum-

mer.”—p. 316. Again, on page 318, we read, “Observers of antiquity, such as Woodward, Wallis, and others, had even (*deja* in French, and *schon* in German) found, &c. On page 320, we read “above” where we should read *below*. In the French it is *audessus*, a misprint for *audessous*; but the English translator faithfully copies it, though the next sentence, if read with care, contradicts it. On page 323, he falls again into the same snare. “We know that the winter of 1829–30 was one of the coldest that had occurred in Europe for a long time; this same winter was so mild in America that there was no ice on the west coast, which permitted Captain Ross to advance so far to the north.” “*Aber dieser Winter war in Nord-America so gelinde, an seine Nordküste war das Eis nicht sehr bedeutend, und Ross konnte deshalb so weit nach Westen gehen.*”

A careless translation on page 327 makes nonsense: “Some ancients considered thunder as produced by emanations arising from the earth. This idea was adopted by many learned men; and although Aristophanes ridiculed it in his comedy of *The Clouds*, yet the fear of the gods always served to weaken it in proportion as the doctrine of Epicurus was the more spread,” “*cependant la crainte des dieux alla toujours en s'affaiblissant à mesure,*” &c. On page 332, Mr. Walker, himself an electrician, adopts the error of the French text, translating “influence” by “induction.” In German it is *Mittheilung*; and this in electricity is the opposite of induction, (*Vertheilung*), as the context is sufficient to show.

A very careless translation arrests attention on page 379. “This table shows that hail falls at all hours of the day, but that it falls more commonly about midday or soon after, at the moment of the greatest diurnal heat. The numbers then diminish in a very regular manner, but at the hours nine and nineteen they are greatest, which might be supposed *a priore*.” Read now the German: “*Diese Tafel zeigt, dass zu allen Zeiten des Tages Hagel gefallen ist, dass er aber zur Zeit der grössten Tageswärme oder etwas nachher am häufigsten ist. Die Zahlen gehen im Allgemeinen ziemlich regelmässig fort, nun um 2 Uhr, 9 Uhr, und 19 Uhr ist die Zahl der Niederschläge etwas grösser, als man es nach den für die benachbarten Stunden gefundenen Grössen erwarten sollte.*” The French translation omits very important parts, though otherwise correct.

The following from page 414, which is literally translated from the French, conveys no idea: "It appears more probable that this rarefaction of the air is limited; for, as each planet draws to itself a part of the atmosphere, refraction, according to a remark made by Wollaston, would be very marked in these planetary atmospheres."* On page 419, another false translation has been copied from the French. "The amplitude of these oscillations, that is to say, the deviations of two successive waves, are not the same for the different rays of the spectrum." "*Die Weite der Excursionen, d. h. der Abstand zweier einander folgenden Wellen, aber ist für die verschiedenen gefärbten Strahlen ungleich.*" On page 427, we read, "The circle No. 4, to which Scoresby assigned a diameter (it should be *semi-diameter*) of about 40° , appeared to be very uncommon; however, (*wenigstens*) I have never seen it more than two or three times in the Alps," &c. The French has the same errors. On page 440 we have *ray* for *radius*; but what is of more importance: — "In gusty weather I have frequently seen rainbows on a blue sky, when drops were falling to the earth, (*sans que les gouttes tombassent sur la terre,*) because they evaporated during their fall." On the last line but three of page 441, we have "*refraction*" for "*reflexion.*"

"*So werden sich beide Bögen dergestalt zeigen, dass jedesmal der Winkel zwischen dem einfallenden und gebrochenen Strahle 41° beträgt,*" is erroneously translated by Martins and Walker, "The two bows will always meet so that the angle between the refracted and the incident ray is 41° ."

A moderate acquaintance with terrestrial magnetism would have saved the English translator from another error. "From this point the western declination diminishes; and, at the east of the United States, the needle points exactly to the north pole," &c. — p. 448. "*Und im östlichen Theile der Vereinigten Staaten,*" &c. The French reads, "*a l'orient des États-Unis.*"

* Es scheint jedoch wahrscheinlicher, dass diese Ausdehnung der Luft eine bestimmte Gränze habe: denn wäre dieses nicht der Fall, und eignete sich jeder Planet von der durch den ganzen Weltraum verbreiteten Materie einen Theil davon an, wie ihn seine Anziehung erfordert, so müssten die Atmosphären welche auf diese Weise um jeden Planeten gebildet werden, ähnliche Phänomene zeigen, als die uns umgebende Lufthülle, und namentlich müsste nach einer Bemerkung von Wollaston die Strahlenbrechung darin sehr lebhaft seyn."

“*Et n'ont l'apparence d'une masse lumineuse continue que parceque les intervalles sont remplis,*” &c., is translated (p. 456) “and which have *not* the appearance of a continuous luminosity only because,” &c. The plain statement “*Eben so wenig lässt sich angeben, ob die Luftpotelectricität bei Nordlichtern eine ungewöhnliche Stärke besitze,*” after passing its two-fold ordeal, reads thus in English: “It is also equally impossible to say whether the atmospheric electricity is generally more powerful than usual.” — p. 461. “*De la force d'impulsion,*” is translated, “the force of the inhalation.” — p. 478.

In many passages where the translation has not perverted the sense, it is frequently inelegant and sometimes ungrammatical. Mr. Walker repeatedly translates *anormale*, “anormal;” *isolément*, “isolately;” *chiffre (eine grösse)*, “a figure;” *tres-propres*, “very suited;” *a la plus grande analogie*, “greatly analogous;” *trop forte*, “higher;” *plus longue*, “larger.” On page 450, we have this passage: “Confining ourselves in the study of terrestrial magnetism, in considering the direction of the needle, is only looking upon one part of the question,” &c.

We have said enough to show that the present translation of Kaempts's meteorology into English fails essentially of giving the author's opinions, or of teaching the truth. It is so overloaded with errors (only a part of which we have had room to specify,) as not to be a safe guide in the hands of the novice; and in its style we look in vain for that neatness, purity, and elegance of diction, which impart a charm to the paths of severe science no less than to the pleasing walks of literature.

ART. IV. *The History of Ancient Art*. Translated from the German of JOHN WINCKELMANN, by G. HENRY LODGE. Vol. II. Boston: James Munroe & Co. 1849. Grand 8vo. pp. 270.

A PROSAIC mind is apt to consider every thing useless which is not practical, and nothing practical which does not minister